REMARKS/ARGUMENTS

Affirmation of Election:

The examiner restricted prosecution to one of Group I (claims 1-13 and 19-38), Group II (claims 14-18). In a telephone conversation with the examiner on June 21, 2005, Mr. Paul White, patent attorney for the applicant, made a verbal election with traverse to prosecute the Group I claims 1-13 and 19-38. The applicant hereby affirms that election with traverse.

Current Status of Application:

Claims 14-18 were withdrawn as a result of the election.

The examiner objected to the claims due to misnumbering. Misnumbered claims 25-28 have been renumbered to 24-27.

Claims 1-10 were rejected under 35 U.S.C. 112, first paragraph because they do not recite a light source. This rejection is now moot due to cancellation of independent claim 1 in this Amendment. Also, claims 1-9 have been canceled and the remaining claim 10 is made dependent on the new claim 28.

Claim 6 was rejected under 35 U.S.C. 112, second paragraph, because it was unclear to the examiner as to how a method step can be a structural limitation for the apparatus. This rejection is now moot due to cancellation of claim 6 in this Amendment.

Claim 21 was rejected under 35 U.S.C. 112, second paragraph, as being unclear and indefinite as not being supported by the specification. Claim 21 is now amended as supported by the specification to recite "determining an initial diffusible hydrogen concentration in the selected portion by multiplying the hydrogen diffusivity rate times by the time since the initial weld process was completed." The Support for this limitation can be found on page 15, lines 11-30, wherein the specification recites the following:

"More specifically and with reference to Figure 4, solutions for the theoretical diffusion equation were generated for different initial diffusible hydrogen concentrations as a function of time with the results being adjusted for the average amount of weld metal per sample and multiplied by the ratio of surface area sampled, i.e., sample area 17, to total area of the welded object. The slopes of theoretical curves resulting from the equation solutions were calculated in 2 hour time intervals in units of milliliter/minute based on weld samples from gas metal arc welding

of HSLA 100 steel..... Significantly. the slope of this curve provides a standard conversion factor that can be applied to each sensor assembly response curve to determine a rate of diffusivity from the weld material, i.e., in units of □liter/minute, which, in turn, can be used to determine the initial diffusible hydrogen concentration in a weld sample by multiplying by the time since the initial weld process was completed."

In view of the foregoing, it is respectfully submitted that there does exist support for claim 21 in the specification and it is not unclear and indefinite under 35 U.S.C. 112 second paragraph. The Applicant submits that this claim is now in condition for allowance and such action is respectfully requested.

Claims 1-3 were rejected under 35 U.S.C. 103(a) as being obvious over Buchanan (USP 5,153,931) in view of Koide (USP 5,445,725). This rejection is now moot due to cancellation of claims 1-3 in this Amendment.

Claims 1-3, 7-11, 13, and 19-23 and 25-27 were rejected under 35 U.S.C. 103(a) as being unpatentable over Jelley (USP 5,107,316) in view of Mansfield (USP 4,221,651). This rejection is now moot as to claims 1-3, 7-9, and 11 due to cancellation of those claims in this Amendment. Claims 10 and 12 are amended to depend from new independent claim 28. New claim 32 is dependent on claim 13 and incorporates the limitations discussed below. New claims 29-31 are dependent on claim 28 and incorporate the limitations discussed below. Claims 19-21, as amended, incorporate new, unique and distinct limitations as will be explained below with the remarks to the new independent claim 28. Claims 22, 23, and 25-27 are not changed. New claims 33-37 have also been added and incorporate the limitations discussed below.

With respect to the Jelly patent the discussion below will distinguish the Applicants claims over Jelly individually and in combination with Mansfield.

The new independent claim 28 recites the limitations of a sensor housing having a leak proof sample chamber enclosing the object to be measured. The chamber as defined in the claims provides a predetermined sample volume within the housing having a hydrogen sensor mounted in a sealed connection to the leak proof sample chamber. A detector and signal analyzer is connected to the sensor housing for receiving reflected light from a layer of hydrogen-reactive chemochromic material of the hydrogen sensor wherein the reflected light is detected and analyzed by the signal analyzer to correlate the variations in the light input to a quantity of hydrogen in the predetermined sample volume and to then correlate such a calculated quantity of

hydrogen to a diffusible hydrogen concentration in the leak proof predetermined sample area of the object to be measured. This claim as amended recites a unique limitation of correlating the variations in the light input to the quantity of hydrogen and then use the calculated quantity of hydrogen to determine the diffusible hydrogen concentration of the object enclosed in the leak proof chamber wherein the physical properties of the chamber are used to calculate the quantity of hydrogen present.

The examiner argues that Mansfield on Column 3, lines 25-29 teaches calculations used to determine hydrogen concentration, calculations which are based on surface are and sample volume. However, this citation specifically states that "The inside diameter of the ring seal determines the area of the mental being analyzed is used in calculating the current density." There is no teaching at all I nMansfield that involves the sample volume in determining hydrogen concentration.

Furthermore, Mansfield's chamber is filled with electrolyte, not hollow, and Mansfield never mentions anything about his chamber having a known volume, let alone a use for such a known volume in determining hydrogen concentration. Therefore, there is no teaching, incentive, or suggestion in Mansfield to leave the chamber empty and to determine and use a known volume of his chamber for determining hydrogen diffusivity or hydrogen concentration, as recited in applicant's new apparatus claim 28.

In view of the foregoing, it is respectfully submitted claim 28 as amended, as well as dependent claims 10 and 12 are unique and distinct from Jelly in view of Mansfield. Claim 19 with dependent claims 20-23, 25-27, and new claims 38-39 incorporate the same limitations as discussed above. The Applicant submits that these claims 10, 12-13, 19-32, 38-39 are now in condition for allowance and such action is respectfully requested.

Claims 1-3, 7-11, 13, and 19-23 and 25-27 were also rejected under 35 U.S.C. 103(a) as being unpatentable over Mansfield in view of Jelley. This rejection is now moot as to claims 1-3, 7-9, and 11 due to cancellation of those claims in this Amendment. Claims 10 and 13 are amended to depend from new independent claim 28. Claims 19-21 are amended, as will be explained in more detail below. Claims 22, 23, and 25-27 are not changed.

Claims 4-6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Mansfield and Jelley as applied to claims 1-3, 7-11, 13, and 19-23 and 25-27 above and further in view of

Benson (USP 5,708,735). This rejection is now moot as to claims 4 and 6 due to cancellation of those claims by this Amendment. Claim 5 is also canceled.

Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over Mansfield and Jelley as applied to claims 1-3, 7-11, 13, and 19-23 and 25-27 above and further in view of Szuchy (USP 4,734,577). Claim 12 is amended to depend from new independent claim 28.

Claim 13 is rejected under 35 U.S.C. 103(a) as being unpatentable over Mansfield, Jelley, and Szuchy as applied to claim 12 above and further in view of Cramp (USP 4,600,310). Claim 13 is amended to depend from new independent claim 28.

Claim 24 is rejected under 35 U.S.C. 103(a) as being unpatentable over Mansfield and Jelley as applied to claims 1-3, 7-11, 13, and 19-23 and 25-27 above and further in view of Carter (USP 6,328,932 B1). Claim 24 is not changed by this Amendment.

With respect to the above claims that have been rejected under 35 U.S.C. over Mansfield and Jelley in view of Benson, Szuchy or Carter or further in view of Cramp, discussion of the Applicants' amended claims with respect Mansfield have already been made. The Applicants' respectfully submit that the arguments made distinguishing the instant claims are applicable to any combination of references the examiner makes. However, the Jelley patent will be discussed first even though the limitations to the rejected claims as amended as mentioned above for the rejection of the claims over Jelley in view of Mansfield apply equally well to the rejections of the claims over Mansfield in view of Jelley and further considered in view of all the other references the examiner combines with the two.

As noted by the examiner, Jelley does not use a hydrogen sensor further comprising a layer of hydrogen-reactive chemochromic material in communication with the leak proof sample chamber. Jelley also does not use either rare earth or lanthanide trihydrides, which are used in applicant's invention. Instead, Jelley uses a multiple quantum well (MQW) structure that is inadequate for the application of determining diffusible hydrogen concentrations of welds for a number of reasons that will be discussed below, but the most important of which is ability to sense hydrogen concentrations accurately over a wide range of hydrogen concentrations.

Jelley's sensor, like the sensor in Benson et al., is designed primarily to detect and signal the presence of gas, e.g., hydrogen, in ambient atmosphere. See e.g., Jelley, column 1, lines 5-11; column 2, lines 40-42, 51-53, and 60-62. This alarm function of detecting and signaling when hydrogen in the ambient atmosphere exceeds a safe threshold is a trigger function, and, as

a trigger function, it only has to be accurate in a narrow hydrogen concentration range, i.e., at or around a safe hydrogen concentration threshold. In contrast, the present invention for determining diffusible hydrogen concentrations in metal welds is a measuring function that has to be accurate over a wide range of hydrogen concentrations. Therefore, the hydrogen sensor systems as well as the incentives and motivations are different.

Therefore, it is significant that Jelley's MQW provides only a slight shift in the absorptive edge to a slightly longer wavelength when hydrogen is present and adsorbed at the surface of the topmost layer of the MQW, which is the functional basis of Jelley's hydrogen sensor (see Jelley, column 4, lines 5-20). Thus, as explained by Jelley in his column 4, lines 32-36:

> If the transmitted/reflected light being monitored is of the correct wavelength, it will now fall within the shifted absorption edge and the detector will register a drop in intensity and thereby indicate the presence of hydrogen.

Therefore, in addition to having only a narrow accurate hydrogen concentration measuring range, the light wavelength and the crystalline MQW materials have to be precisely tuned to meet these tight absorption and wavelength tolerances, which is not only expensive and difficult to achieve, but it also makes the system very expensive and renders it sensitive to temperature changes and other accuracy issues.

In contrast, the transition metal oxides and rare earth and lanthanum dihydrides used for the applicant's hydrogen sensor materials are variable light transmissive materials that work over a very broad band of light, e.g., from about 600 to 1,200 nm so almost any kind of light in that range, from broadband white light to specific wavelength laser light, can be used in this invention. Thus, they are a substantial improvement in optical hydrogen sensing, especially for use in measurements as opposed to threshold signaling.

Even if there was an incentive or motivation to modify Jelley to have an accurate hydrogen concentration measuring capability over a wider hydrogen concentration range, Benson et al. would not help. In fact, the Benson et al. reference neither teaches nor has any significant hydrogen concentration range measuring capability at all, as will be discussed in more detail below. Therefore, there is no teaching, incentive or suggestion in Benson et al. that anything in Benson, including the tungsten trioxide used by Benson, would provide any broader

hydrogen concentration measuring range. In fact, Benson teaches just the opposite, as will be explained in more detail below.

The examiner's assertion in the Office Action, paragraph 13, that, "It would be obvious to one of ordinary skill in the art to modify the Mansfield Jelley sensor with transition metal oxides such as tungsten trioxide disclosed by Benson in an optical hydrogen sensor to make a sensor with a faster response time." However, that assertion is misplaced for several reasons.

First, there is no indication in Jelley or any reason to believe that the Jelley MQW is slow. On the contrary, Jelley's MQW is a semiconductor device that would be expected to respond almost instantaneously to the change in electric field brought about by the presence of hydrogen on the surface of the topmost layer of Jelley's MQW (See Jelley, column 4, lines 13-31), and there is no basis in either Jelley or Benson et al. to believe that the palladium catalyst in Jelley would catalyze molecular hydrogen to atomic hydrogen any faster for a transition metal oxide from Benson et al. than it does for Jelley's MQW. Therefore, there is no teaching in any of the prior art references that substitution of a transition metal oxide from Benson et al. for the MQW in Jelley would make the Jelley sensor have a faster response time. Consequently, the examiner's premise for the obviousness rejection of the subject matter in claims 4-6 (now in new claim 28) under 35 U.S.C. 103(a) based on Mansfield and Jelley in view of Benson et al. is inappropriate.

Second, the hydrogen sensor of the present invention is used for measuring hydrogen concentrations in metal welds, which requires accuracy over a wide range of hydrogen concentrations, whereas both Jelley and Benson et al. are sensors used to generate a signal when they detect the presence of hydrogen in the environment, which requires accuracy at a low hydrogen concentration, but not over a broad range. Indeed, the Benson et al. sensor with its tungsten trioxide has a very narrow hydrogen concentration measuring range, as will be discussed below, so Benson et al. provides no teaching or motivation to substitute tungsten trioxide or any other material for Jelley's MQW layer in what the examiner referred to as a Mansfield Jelley sensor. Only the current patent application, not Jelley or Benson et al., addresses the measurement accuracy range. Only the current patent application describes the measuring function and tests with tungsten trioxide (WO_3) that showed that the response of the sensor layer 28 was linear over a wide range of hydrogen concentrations from 200 to 1,000 ppm (See Specification, page 14, lines 9-22). Therefore, only improper hindsight reconstruction of

the applicant's invention using the applicant's own specification and claims would show that transition metal oxides, e.g., tungsten trioxide, is so well-suited and effective for measuring, as distinct from just sensing the presence of, hydrogen for determining diffusible hydrogen concentration in metal welds according to this invention.

Benson does not direct light through the tungsten trioxide, as is described and claimed in the present patent application. Benson never even mentions the variable transmissivity characteristic of tungsten trioxide, and Benson, like Jelley, does not have any ability to measure hydrogen concentrations over a broad range, so there is no teaching, suggestion, or incentive to replace the multiple quantum well (MQW) semiconductor structure of Jelley with the tungsten trioxide of Benson, as asserted by the examiner. On the contrary, Benson, like Jelley, is for the purpose of detecting the presence of gas, e.g., hydrogen in the environment. See, e.g., Benson et al., column 1, lines 11-14 and 41-50; column 2, lines 57-58; column 3, lines 59-60; column 4, lines 47-49; column 9, lines 54-56; column 10, lines 9-10; and column 11, lines 37-39. Therefore, there is no need for a capability of accurate hydrogen concentration over a broad range, and, the plasmon resonance of the tungsten trioxide layer used as the operative characteristic of the Benson hydrogen sensor occurs only for a given wavelength of a given incident angle (the resonance angle) of the light on the layer. Further, and very significantly, only the portions of the reflected beam that have wavelengths close to the resonant wavelength can pass through Benson's optical filter 28 to reach the photo detector 26 (see Benson, column 8, lines 38-40), and even a very small amount of hydrogen causes a strong shift in resonant wavelength away from that which can pass through the optical filter 28 (See Benson et al., column 6, lines 38-48). Therefore, the detection of the presence of hydrogen with the Benson et al. system is fast and sure, but it has only a very narrow accurate hydrogen concentration measurement range, and it does not teach anything about how to make a hydrogen sensor that would have a broad, accurate measurement range suitable for use in diffusible hydrogen concentration determinations as is needed for this invention.

Other distinctions of the present invention over Jelley are significant. For example, Jelley's MQW's 16 of alternating layers of GaAs/AlGaAs, etc., are crystalline semiconductor structures that have to be grown on crystalline substrates 10. Therefore, Jelley also needs and discloses complex optical coupling components, including not only the two optical fibers 20, 24, but also two prisms 28, 30 set at precise Brewster's angle, the crystalline substrate 10, doped

layer 14 of AlGaAs, etc. These crystalline structures are expensive, need careful polishing of the crystalline substrate, require expensive semiconductor fabrication facilities, etc., and the optical components are difficult to assemble, mount, align, etc. In fact, there is no teaching of how these components could be mounted in Mansfield's hydrogen sampler apparatus, and there is no incentive or motivation to do so, other than an attempt at hindsight reconstruction based on the teaching of the present invention.

In Summary, the uniqueness of the limitation described above distinguishes all the claims of the applicant from the art cited by the examiner whether considered individually or in any combination. That being a hydrogen sensor apparatus and method that utilizes a unique apparatus and method for correlating the variations in the light input to the quantity of hydrogen and then use the calculated quantity of hydrogen to determine the diffusible hydrogen concentration of the object enclosed in a leak proof chamber wherein the physical properties of the chamber are used to calculate the quantity of hydrogen present.

All of the claims as now amended are believed to be allowable for the reasons explained above. If there are any remaining issues, the examiner is requested to call the applicant's attorney at the telephone number listed below.

Respectfully submitted,

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